

National Aeronautics and Space Administration

Office of Space Science

**STRUCTURE AND EVOLUTION OF THE UNIVERSE
SUBCOMMITTEE**

**OF THE
SPACE SCIENCE ADVISORY COMMITTEE**

April 9-10, 2002

Washington, D.C.

MEETING MINUTES

Dr. Edward W. Kolb
Chair

Dr. Paul Hertz
Executive Secretary

STRUCTURE AND EVOLUTION OF THE UNIVERSE SUBCOMMITTEE (SEUS)

April 9-10, 2002

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***Meeting Report Prepared By:
Linda D. Voss, Consultant
RS Information Systems, Inc.***

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*Tuesday, April 9*Welcome/Introduction

Dr. Edward "Rocky" Kolb opened his first meeting as Chair of the Structure and Evolution of the Universe Subcommittee (SEUS) by having Executive Secretary Paul Hertz review the rules for Federal Advisory Committee Act (FACA) committees for the benefit of the new members. On the agenda was a presentation on the roadmap. The committee was to be informed of roadmap directions and reach some agreement about them. The committee will see the roadmap in August at the next SEUS meeting, but should weigh in on major issues at this meeting. The chair was also seeking issues to raise with Astronomy and Physics (A&P) Division Director Anne Kinney. The committee will be getting mission updates and plan future meetings.

Structure and Evolution of the Universe (SEU) Theme Update

Dr. Paul Hertz reviewed SEUS-specific missions in operations, development, and concept stage and reported on Research and Analysis (R&A) programs, Public Affairs (PA) events, and Education and Public Outreach (E/PO) events. He noted that National Science Foundation and Department of Energy colleagues had been invited to observe NASA making strategic plans, which is not common to other agencies.

Dr. Hertz reviewed the status of the HST, Rossi XTE, VSOP-HALCA, 2MASS, SWAS, FUSE, HETE-2, MAP, XMM-Newton, and Chandra XO missions. The HALCA Space VLBI project terminated March 8; science analysis continues as a Space VLBI task; and NASA withdrew from collaboration with the Japanese.

The Far Ultraviolet Spectroscopic Explorer (FUSE) was in the middle of terrible problems in December. It had lost two reaction wheels, leaving it with two of three it needed to operate. Orbital, Johns Hopkins, and Goddard performed a software miracle and regained science operations through the use of a magnetic torquer bar for attitude control. The science is limited to within approximately 34 degrees of the orbital pole, but 65% of sky will be seen over time. The program is hoping to extend the spacecraft's ability through additional software revisions. The spacecraft lost two months of operations, it's less efficient (it takes more time to slew and settle), and it's more manpower intensive. So it gives less science for higher cost, but at least it's operating.

Seven missions will undergo Senior Review this June to rank them by science value to determine allocation of limited available MO&DA funding for FY03-04. SWAS and 2MASS will terminate in FY02 without an extension. MAP's prime mission ends in FY03-04. HETE, FUSE, and RXTE were provisionally extended through FY03-04. The extension will be reviewed. The prime missions of XMM, GALEX, Integral, and Swift extend through FY04. XMM will get a provisional review. Exact funding available awaits resolution of several issues, including FUSE recovery costs and the Swift GO program.

Dr. Hertz updated the committee on mission statuses. GALEX has some challenges, but is close to launch. CHIPS is the only University Class Explorer (UNEX) mission. A problem with transmitter acceptance was solved by procuring a commercial transmitter. The cost-capped GP-B mission is slipping by two or three months with launch no earlier than December. Integral is looking good for launch this fall.

Swift is facing cost and schedule challenges. The BAT is more complex and time consuming than planned. Astro-E2 passed its confirmation review. It is slated for an '05 launch. Herschel and Planck have an '07 launch. The budgets were augmented so that NASA could meet its obligations to ESA. The Planck

cryocooler is more expensive and took longer than planned. The safety issues for Balloons were resolved. WFF safety criteria were changed to be consistent with other NASA ranges.

In response to a question from the chair on funding the Herschel increase, Dr. Hertz explained that band 6, the shortest wavelength in the HIFI detector, was not part of the original requirement for Herschel because its development was unsure. When researchers were able to include band 6, the budget was increased to allow the progress in the instrument.

The chair noted a pattern of increasing yellow as programs got closer to launch. Dr. Hertz agreed, explaining there is more flexibility for resolving problem away from launch. When problems arise close to launch, the program needs more money or a slip in launch date, which costs more money, to resolve problems. The SEUS missions have more green than Origins, but yellow nearing launch is not unusual.

Gravity Probe B (GP-B) continues meeting all its critical milestones. At this point, all schedule slack has been eaten up. The program is figuring the cost impact of a three-month launch slip. Dr. Hertz noted that the community had mixed feelings about GP-B, but NASA is committed to doing the science and launching the spacecraft. The launch slip on a Delta is still under discussion.

Missions get higher priority in the budget as they get closer to launch. GP-B and SIRTf are high priority now. GALEX doesn't have any budget problems. It is in the Explorer program, not the A&P budget. Joel Bergman asked what problems the Space Infrared Telescope Facility (SIRTf) was having. The flight software scope was underestimated and development was slowed down. It is looking at a significant launch slip of six to eight months and a cost hit.

Rocky Kolb asked if all problems would be solved within the A&P budget. Dr. Hertz replied that they would. The was the number one rule from the reorganization last year that all programs have to solve their cost overruns within their own resources.

Research programs were on track for 2002. High energy astrophysics solicitations are coming in. The office is looking for reports from workshops initiated by the community looking at missions, instruments, and directions for ultraviolet science.

Dr. Hertz thanked Lynn Cominsky, who has completed her term as HEAD press officer, for the huge service she gave to SEUS programs over the last six years. The new press officer is Ilana Harrus.

Small Explorer (SMEX) is in the middle of downselections. Phase A studies for one MO (SPEAR) and six SMEX—AIM, HNX, JMEX, PRIME, SPIDR, STEP—missions are due in December. Two SMEX missions will be selected for flight after a competitive Phase A.

Medium-class Explorer (MIDEX) proposals have been received (43). Selection of four Phase A studies will be next month. Two will be selected for flight.

An Explorer Workshop in Washington last month with the community had discussions and give-and-take on policy embedded in the Announcements of Opportunity (AO). Launch vehicles and export control were hot topics. There were requests for clarifications, but little questioning of the overall program.

The next SMEX AO will be released no earlier than December or January. Proposals are due three months later, but a draft release comes out three months prior to the formal AO. The schedule slip is due to manpower problems, not cost problems from current missions.

The committee discussed Long-Duration Balloons as mission of opportunity and Explorer missions.

The committee discussed concerns with the availability of small launch vehicles. Dr. Hertz said small launch vehicles were expensive because there is no commercial market for them. Pegasus is well priced for NASA, but it's not clear there's enough market outside NASA for Orbital to make money. The Delta 2 is being phased out. NASA is not allowed to buy a launch vehicle outside the United States. Foreign partners

can contribute them. Joel Bregman suggested the law might be modified for light vehicles. He asked if partners have launch vehicles. The chair mentioned launch vehicles were discussed at the Space Science Advisory Committee (SScAC) meeting. NASA is a small player in the launch business and does not control the market.

Dr. Hertz offered the example of shared launches from the Thermosphere-Ionosphere-Mesosphere Energetics and Dynamics (TIMED) mission, but it ties mission schedules. TIMED sat for one year, at a cost of \$10 million, waiting for the other mission. It would have been cheaper to buy an entire launch. That's the risk.

Lynn Cominsky has been working with Roy Gould on E/PO for Chandra and other missions. They have an 18-item package of SEU materials that includes Exploring the Universe, mission paraphernalia, posters, a Chandra false coloring book, and CDs. They have given out 2,000 of the packages. They were very popular at the National Science Teachers Associations meeting. The NASA booth ran out. Dr. Cominsky invited anyone who wants a package to let her know.

Astronomy & Physics Division Update

Dr. Anne Kinney, A&P Division Director, discussed current budget challenges by launch date. The budget year was difficult with GP-B, Herschel's band 6, Planck's cryocooler, and SIRTf. The next nearest launch date is SIRTf with substantial delays that will cost \$100 million. Of that, \$40 million comes out of operations, which does not require extra money in the system. Money was taken out of Starlight, which was grounded to a ground rather than flight demonstration. Starlight was hard to ground. The program was well managed, but the money was needed for other priorities.

Everyone is pleased so far with the roadmap. The Beyond Einstein vision will be the top priority. Dr. Kinney did not have a feeling about its priority in the Agency. It's an important activity.

Dr. Kinney thanked Joel Bregman and Kathy Flannagan for leading working groups for the Astronomy and Physics Division so that the chair and co-chair sit on Origins and SEU. The division needs cohesive community advice. She wants independent group discussion in the context of everything else that needs more funding in A&P, trying to keep advice within a group sounding board with an understanding of all topics. The NVO science team briefs A&P and NSF this week.

The Astronomy and physics and science archives working groups are meeting this month and will report at the next SEUS meeting.

The A&P has been in place since July. The staffing has settled down at 30 from 26. A&P is growing slowly. A few more people are expected. Excellent people have been recruited to join the excellent people already there.

The chair asked for feedback on the roadmap physics and themes.

Dr. Kinney said she didn't want the two roadmaps (SEU and Origins) at first, but changed her mind. She feels it's a strength to formulate the vision in two ways. The problem with SEU is it got everything that Origins didn't want. It doesn't work to take an initiative to OMB that's a shopping list. SEU could have more than one initiative besides Beyond Einstein, but it has to be earned. The Hubble Space Telescope earned Origins. Chandra in some sense has to be "earning" Beyond Einstein. She didn't know what would earn beyond that.

The committee discussed what the terms meant and their implications. Origins and SEUS are individually responsible for their projects. If a problem is big enough and important enough, then everyone ponies up. Chandra is one of the great observatories. When its problems came up right before launch, it was kicked up to Code S and became everyone's problem.

Dan Lester asked what sort of metamorphosis of SEUS Dr. Kinney would envision if Beyond Einstein succeeds.

Dr. Kinney advised getting another mission before making any changes. Origins and SEU could get together. The only real way to drive a program line is through the science questions. There's no reason to separate Origins and SEU if the science issues overlap. The themes are so useful in Washington, D.C. to describe the need for funding, but the science community doesn't care except as a tool to fund science.

Roadmap Team Update – Strategy

Dr. Sterl Phinney discussed the roadmap. SEUS must approve it and direct the team. The team's instructions were to identify the highest priority long-term science objectives, justify them, and articulate them to the public and the science community. The team could make suggestions for the out years and should identify technology needs to make this happen.

The Astronomy and Physics Division has two themes:

- Astronomical Search for Origins
- Structure and Evolution of the Universe

Origins has two pieces: the search for life and galaxy/star/planet formation. SEU is everything else—stellar end points, physics in extreme environments, nucleosynthesis, the birth of the universe, fundamental physics. SEU owns dark matter and dark energy.

Origins is the role model. They have a program line. Sun/Earth has a program line. Headquarters thinks it would be a good idea for SEU to get a program line. The missions of the program line have to be tied together by the science and technology.

SEU's near-term top priorities in the previous roadmap were Con-X, LISA, and ACCESS. The Cosmic Journeys proposed program line died when Bush took office and said there would be no new initiatives.

The Advanced Cosmic-Ray Composition Experiment on the Space Station (ACCESS) was originally put in the roadmap. Now it is competing in MIDEX. Originally, it couldn't apply for Explorer money because it was attached to the Space Station. That's been fixed.

SEU did well in the Decadal Survey with five missions ranked including the Gamma Ray Large Area Space Telescope (GLAST). The previous roadmap and the NAS Decadal Survey recommendations are too diffuse too numerous for a single program line, so the possibilities had to be prioritized. The roadmap team was tasked to develop both the roadmap and the highest priority program line to keep the two coherent and cohesive. Community input comes from NAS. Also, the roadmap team solicited white papers that were due January 31. They are posted at <http://universe.gsfc.nasa.gov/roadmap.html>.

Dr. Phinney reviewed the roadmap process and schedule. The roadmap team was reconstituted in September. The team has held a number of meetings and teleconferences. They reviewed the previous roadmap missions and defined the science questions. The technology team is collecting technology needs. They decided they needed an R&A working group. Kathy Flanagan was volunteered.

Dr. Phinney presented a concept and outline for SEUS's approval. The team has to produce another draft in the next couple of months. An electronic version will go out to the subcommittee for review. The final draft will be ready for SEUS's August meeting. The roadmap is due September 1. Goddard will print a glossy report. In November, the Office of Space Science (OSS) will develop the overall strategic plan using the theme's roadmaps.

The team conceived the roadmap as two self-contained parts. One will cover the highest priority science questions, and the missions SEU is proposing. The second will cover other priority SEU science, missions, technology, and R&A.

The highest priority program is called Beyond Einstein – from the Big Bang to Black Holes. Constellation-X (Con-X) and the Laser Interferometer Space Antenna (LISA) are to be the missions included in the program. They are related scientifically through black holes, relativity, and fundamental physics. The science questions are linked by the Beyond Einstein vision covering the Big Bang, gravitational waves, and the nature of space and time. These questions are all

popular with the public. Not all of the NAS Decadal Survey recommendations are in this program. Some of them are in the second set of priorities. Con-X and LISA are at the top of the NAS survey. But they are still open to discussion.

Dr. Phinney presented the fundamental science questions and objectives. Some wordsmithing was done.

The first program has three elements:

1.) The Beyond Einstein Flagship missions:

Con-X uses x-ray-emitting atoms as clocks to follow the fate of matter falling into black holes. LISA studies black holes through the gravity waves they emit when they merge.

2.) The Einstein Probes:

These are competed, peer-reviewed missions of \$300 to 450 million. There are three missions: Dark Energy Probe, Big Bang Probe, and a Black Hole Survey Probe. One will be launched every three years starting in no earlier than 2010. The three science objectives are:

- Determine the nature of dark energy.
- Search for the signature of inflation in the microwave background.
- Survey for black holes.

These are not in chronological order. The mission that satisfied the last objective is technically ready and probably will go first.

3.) The technology program:

The program is focused on developing technologies to enable vision missions after 2015. Some of the science to be done is imaging matter near the event horizon of a black hole and detecting gravitational waves from the inflationary epoch.

The vision for second part of the roadmap is Cycles of Matter and Energy. Four missions were selected for useful discussion: ACT, Gen-X, SAFIR, and SUVO.

The Office of Space Science and Budget Update

Dr. Edward Weiler briefed the SEUS on the President's budget. OSS got a major increase not counting the transfer of the Deep Space Network (DSN). Europa Orbiter was cancelled but replaced by New Frontiers. The agency budget only went up by \$100 million, but OSS increased quite a bit. OSS's run-out budget in '07 will almost be up to the level of human space flight.

Dr. Weiler discussed changes in the content of the program. The budget is ramping up for GLAST. New Frontiers is coming up. Missions operations jumped up from the DSN transfer. The technology budget is up to support the nuclear systems initiative.

The Nuclear Systems Initiative (NSI) for planetary missions is a \$980-million program. This funding is on top of the generic in-space propulsion initiative from last year. It has three elements:

- nuclear fission electric propulsion research
- nuclear fission power research
- radioisotope power (Radioisotope Thermoelectric Generators (RTGs)) development. OSS will build some old-fashioned ones and develop more advanced RTGs.

The nuclear fission power research is just research. The program has to start by rebuilding the infrastructure. It is not launching in this decade. OSS knows how to build ion engines at a 1,000 watts, but not how to use megawatts of power for an engine. More than 50% of the program is competed through NRAs. The office hopes to interest universities. Dr. Weiler feels nuclear is the future of exploration. DOE is a critical partner who can buy nuclear fuel.

The Mars Smart Lander slipped from '07 to '09 to incorporate nuclear power. It has a landing system with fear programmed into it: it moves when it perceives danger. That capability will be needed for sample return. Putting nuclear power on board will extend the mission from 3-6 months to 5 years. It will enable the rover to drive to a

location rather than having to land there. The bandwidth goes way up. The rover can work 24 hours a day. This is why Viking lasted 5 years. Everything increases by a factor of 10 every time you add an RTG to a mission.

The New Horizons Pluto mission funding was not continued in the President's budget; the mission will not continue unless it is put back in by Congress.

The Hubble servicing mission, SM3-B, was a success, but was delayed, and the cost overrun cost a few million dollars. Hubble's return to Earth is planned for 2010. Funding for the Next Generation Space Telescope (NGST) increases as a function of decreasing Hubble spending. NGST's launch date is under review, but both the Administration and Congress have clearly stated their desire for NASA to be as aggressive as possible.

OSS receives management responsibility for DSN as part of a resolution of a shortfall in space operations. OSS will have a seat at the table for the other part of the Space Operations Management Office (SOMO) issue, which is the Tracking and Data Relay Satellite System (TDRSS). Management of SOMO will be at NASA Headquarters, not Johnson Space Center any more.

Dr. Weiler reviewed program success stories and the programs that are a concern. He felt there was a fundamental problem with how flight software is estimated. He emphasized the importance of good estimating and managing. Hubble pictures since the repair mission are meeting or exceeding expectations. When the cryocooler comes up, it will resurrect a \$100-million instrument that has been dormant. Chandra and HST have received a lot of media coverage.

The subcommittee discussed the relative wisdom of investing in nuclear, commented on the New Frontiers being Piled with more NASA supervision, suggested the DSN needed upgrading, and asked about the future of science on the space station. Rocky Kolb commented that OSS has a reputation for taking care of its own problems. Concerns should be discussed and dealt with. The SScAC has voiced their concern about using the word "nuclear."

Dr. Weiler responded that he felt nuclear was the right thing to do. DOE is fully involved with NASA to design and build RTGs. The nuclear industry is participating. He did not want to build more RF dishes for DSN, because of the possibility optical communications will be the future. JPL is looking at how best to interface with the infrastructure. They will keep up with receiver technologies. The first move will be from X band to Ka band for a factor of four increase in bandwidth.

OSS has zero budget for doing science on the space station. Dr. Weiler speculated that it might be 4 or 5 years before a new political attitude allows science and the possibility of big astronomical instruments on the station.

Dr. Weiler approved of the Beyond Einstein roadmap concept.

New XMM-Newton Results

Jane Turner reported on X-ray Multiple Mirror (XMM)-Newton recent discovery in x-ray absorption in the intergalactic medium. The results have not been published yet. XMM looked at x-ray absorption against bright AGN to detect a tenuous "web" of x-ray emission in the near- and low-red shift phase. The spectrum observed indicates the constraint on the density and extent of the "web" and puts it out beyond the Magellanic Cloud. Given consistent detection in three lines of sight, it indicates the web is pervasive across the sky.

XMM data following up from the ASCA mission was submitted to Nature on the relativistic effects in emissions from an accretion disk around a massive black hole.

Roadmap Team Technology Update

Dr. Steve Kahn said not a lot of progress has been made on the technology roadmap so far. The Technology Working Group, which includes Simon Swordy, Phil Stahl, Chris Schwartz, Steve O'Dell, and Harvey Moseley, has a teleconference Thursday to formulate questions for technologists, who will be presenting from the missions.

The team intends to recommend an explicit technology program in addition to mission technologies. They envision some form of early NRA for technology research programs from proposed technical approaches for missions. Reviews of the research can be the basis for an assessment of a mission's technological readiness. Also, the team needs to assess the technology development needs of missions outside the Beyond Einstein program so they can be included broadly in an A&P-wide technology program and potentially overlap with Origins. There will be overlap with the R&A section of roadmap. Most missions have clear technology drivers.

Dr. Kahn said so far the technology team read the technology white papers and developed the Beyond Einstein concept. After the meeting in May, the team will be at the nuts and bolts level. Even just Beyond Einstein has seven presentations about subsystems and technology drivers.

Members of the committee raised the issue of sectors of the community not represented in roadmap missions.

Roadmap Team Update – Roadmap 2

Dr. Sterl Phinney represented the second part of the roadmap as making the science case for the rest of SEU not in Beyond Einstein this includes the missions: Advanced Compton Telescope (ACT), Gen-X (high sensitivity x-ray imaging), Single Aperture Far-IR Telescope (SAFIR) (cooled, 10-meter class), and SUVO (optical UV spectroscopy).

The second roadmap program, Cycles of Matter and Energy, will have its own technology section. The Research Focus Areas are from the previous roadmap, Cosmic Journeys.

The committee discussed focusing the Beyond Einstein program line and discontent in the community left out.

Paul Hertz said, for the purpose of the Beyond Einstein program, the science objectives are set in stone. How much flexibility there will be to revisit the science questions will be determined by how the program is implemented. Einstein Probes has to match the Beyond Einstein theme. SEU doesn't want to get large Explorer-class missions at the expense of large observatories like Solar System Exploration got New Frontiers.

Dr. Phinney explained Einstein Probes are to quickly respond to scientific questions, which is why dark energy is there, when it is not in the Decadal Survey.

Harold Yorke suggested making the bullet items of scientific objectives a little more general for the second roadmap.

Charles Dermer suggested three alternative science topics: cosmology, black holes, and evolution of structures.

Rocky Kolb suggested the message was that those left out of Beyond Einstein are not forgotten, and it won't help to sabotage the highest priority program.

The chair asked for suggestions in how to communicate the roadmap to the broader space science community to get them on board.

- Speak to AAS meeting.
- Also American Physical Society (a big leverage event).
- Consider HEAD meeting next week.
- FAQ page on the web.
- Talk to the scientific community. Maybe get Ed Weiler for the technical meetings.

Roadmap Team E/PO Update

Ray Gould presented key points for the roadmap's E/PO component. The team wants to underline the successes being built upon, identify educational opportunities, and document support and evidence for the public's interest in the theme.

- The roadmap captures the imagination of the public. It is penetrating the culture.
- Public involvement is high. The show, Journey to the Edge of Space and Time, increased attendance at planetariums in Boston and Philadelphia by 25%.
- Two of the three science questions are included in the National Education Standards. (The National Science Education Standards are published by the National Academy of Sciences.) Black holes are included in the AAAS benchmark standards for literacy, which some teachers consider helpful. NASA is a big supporter of education for teachers.
- Many education opportunities flow from the roadmap. Real-time science in exhibits that can be updated are the latest thing for museums. Planetariums can put up the latest web data.
- The theme appeals to a diversity of the public, which is important because of the changing U.S. demographics. It helps makes math and science relevant to students of other cultures.
- The public is asking the same questions that SEU is.

Paul Hertz said the mandate for doing E/PO is NASA's. OSS gets credit from Congress for education, inspiring the public, and nurturing the next generation of scientists. E/PO is the right thing to do.

Joel Bregman offered that the OSS educational program is very broadly based with—for teachers—professional development programs and meeting with scientists. It also has internships. A lot of the materials for teachers are web based. Soon they will be able to get CDs.

Lynn Cominsky explained teachers have to teach what is in the standards, which differ from state to state. One of E/PO's long-term issues is finding a warm and fuzzy home for astronomy in the classroom. There is almost nothing in the curriculum. Coupled with the back-to-basics trend, it is a problem that E/PO is trying to reverse.

Kathryn Flanagan said E/PO should have separate sections in the first and second roadmaps. Much of the 2000 roadmap E/PO material is relevant to the second roadmap.

Committee Discussion on Roadmap High-Level Questions

Dr. Sterl Phinney presented the philosophical questions for the Beyond Einstein program line:

- What made the Universe exist?
- Does time have a beginning and an end?
- Does space have edges?

The committee discussed wording of the Objectives:

- What caused the Big Bang?
- What happens to space, time, and matter at the edge of a Black Hole?
- What is the mysterious dark energy pulling the universe apart?

The committee discussed the basis for prioritizing the missions. Rocky Kolb said the reason the Decadal Survey and SEU priorities came out different was because of different metrics on what makes a good program. The budget concept of program lines is less than 10 years old. Funding used to be by mission.

Rocky Kolb raised the issue of how a high-priority mission that does not fit into the program line gets implemented. Dr. Hertz replied, by asking for new money for a new mission. Dr. Kolb countered with it being at a big disadvantage because a mission falls between the cracks, not because the science is less worthy. Dr. Hertz pointed out that the budget process does not map directly to science priority and that NASA is highly managed as an agency.

Dr. Kolb suggested that the subcommittee, as a reality check, look at all the possible missions in SEU. If OMB gave an amount of money and just said to rank the missions and they would draw a line when the money ran out, would it look much different than the Beyond Einstein program line? Harold Yorke felt the roadmap reflected the makeup of the SEUS and that it was important to make the argument to the community for what can be sold. Lynn Cominsky commented the program line would look the same unless the team ignored the Decadal and other surveys.

The plight of Single Aperture Far-IR Telescope (SAFIR) was raised. Dan Lester said it is listed as a new start for this decade. The science for that mission is valued. But what is the mechanism for taking advantage of that value? If people vote their wavelength of interest, SAFIR will always get outvoted. How does one move forward the missions in the second roadmap? Ned Wright pointed out SAFIR was in the Decadal Survey and a top priority in 1980. One creative solution suggested was the GLAST model of forming its own community and lobbying for it at conferences and with reports. When there was a budget opportunity, it was put forward.

Wednesday, April 10

Discussion of Issues To Be Raised With Kinney/SScAC

Dr. Rocky Kolb opened the meeting Wednesday by asking for issues to bring up with Anne Kinney. Issues raised were the total number and type of missions that should be in the second part of the roadmap, what is to be done with UV and IR community who drop bridge the interface between SEU and Origins, how to coordinate the second roadmap with Origins, whether three probes was the right number for the program line, and the number and specificity of Cosmic Probes.

Simon Swordy was interested in how to get the support of the rest of the community. He was not clear why SEU had to have such a restricted list of items for the rest of the community, but if people in other parts of SEU are included, it will help get needed support. He was also interested in a plan for how to use Ultra Long Duration Ballooning (ULDB).

W. Vernon Jones of NASA Headquarters updated the subcommittee on ULDB. The original strategy was to make ULDB a University-Class Explorer (UNEX). That program is no longer funded for new selections, though it still exists to complete CHIPS. Balloon missions will have to compete in mission-of-opportunity Explorer competition. If selections are not made regularly, the infrastructure is lost. There is a process whereby conventional balloon payloads can be funded through the SRT program. If some other disciplines could support some low-cost payloads, it might provide a bridge between regular balloons and ULDB to get some payloads to keep the program going. A typical ULDB mission is \$20 million, which is too big for the SRT program. The balloon is only \$600,000. Dr. Jones felt UNEX had a place. The Explorer program needs a different range of mission category. There is a category for less than \$18-million missions. The low end is \$10 million.

The chair agreed to solicit feedback on the range and directions of missions in the second roadmap, reiterate to Anne Kinney the problem of not including the entire community, which she possibly plans to resolve under the umbrella of the A&P technology program, and raise the ULDB issue.

The committee discussed various missions and their relative merits.

Chandra Space Science Update

The subcommittee's discussion was interrupted as the subcommittee reconvened in the NASA Auditorium for the Chandra Press Conference.

Mission Updates 1—Status of Operating Missions

Microwave Anisotropy Probe (MAP)

Dr. Gary Hinshaw reported on MAP, the first MIDE mission in astrophysics. The mission is primarily a collaboration between Princeton University and Goddard Space Flight Center, including UCLA, Brown, and British Columbia universities. The mission is to map cosmic back ray background over the whole sky map to capture the afterglow light from the Big Bang. This will be the most sensitive, complete full sky map. MAP was launched in launched June 30, 2001, to follow up on the 1989 COBE map.

Cosmology is advancing on many fronts, particularly the measurements of matter. Ninety-six percent of the stuff out there is still completely unknown. Dark Energy is one of most interesting stories in cosmology. CMB is very isotropic, one of the major pieces of evidence for current Big Bang theory.

MAP will get results previously missed by models and not well measured so far. Its instruments include back-to-back differential microwave radiometers with warm and passively cooled stages. It has 10 differential microwave receivers allocated over five frequency bands from 22 to 94 Ghz.

Systematic errors drive the design of the mission. MAP maps 30% of the sky in an hour of scanning. Instrumentation is precise. Sensitive thermal monitors measure up to 100 microKelvin, so they can monitor instrument gain.

The instruments are operating well. Ten channels are on track. The spacecraft has plenty of fuel. In February, it lost half a battery cell out of 22, leaving plenty of margin. A November solar storm put MAP in safe hold. Researchers lost 40 hrs of science data. The spacecraft downlinks once a day for 90 minutes. While MAP is funded for only 2 years of operation, the team will propose for extended operations this summer. COBE was proposed for 1 year and ended up flying for 4 years. There is a long to do list for processing and validating the data. The first results should be out around January 2003.

There was some discussion of comparisons with the upcoming ESA Planck mission.

Chandra

Dr. Martin Weisskopf reported that the Chandra Observatory is superb: operating smoothly and doing outstanding science. TRW and partners did a tremendous technical job building the observatory. Chandra is fueled for 30 or 40 years. NASA funding is committed for the next 7 to 8 years.

There have been some problems. The x-ray telescope focuses low energy protons that reduce the energy resolution of the ACIS detector. The team has figured out how to avoid further damage, but molecular contamination is building up on the CCDs. Normally, the team would heat them up to bake off contaminants, but that makes the proton damage worse.

The team just sent out the call for proposals for fourth observation cycle. The number of proposals has gone up as the community learns what it can do with x-rays. Funds were redistributed to include theory proposals.

Chandra has joint observing time for multi-wavelength observations with Hubble (also XMM, NOAO, NRAO).

The program has an emphasis on E/PO. It has had six Space Science Updates and would like more. The mission's educational component has won the national A&S award and will be featured in a "short," 12-page spread in National Geographic.

Some of the highlights of the science are x-rays seem to be more ubiquitous than previously thought. Interesting results on planets have been obtained. Jupiter's x-ray emission is located at high latitudes, and it pulsates unrelated to rotation.

Mars is on the list for Cycle 3 observations. Chandra has surveyed the galactic center. That data will be mined for neutron stars, supernova remnants, etc. It resolved the M15 x-ray binary into two objects. Chandra can see a more complete set of x-ray-emitting objects in globular clusters and study jets in distant galaxies.

Chandra Deep Field north and south surveys are 80 times deeper at soft energies and 800 times deeper at hard energies. Chandra looked at the three most distant quasars. The x-ray properties are similar to local ones. People are using stacking analysis to add up spectra and are finding changes in x-ray properties with star formation rate. Researchers can use x-rays as a probe because they don't have to worry about absorption. Chandra deep surveys are the best tool for probing the "dawn of the early universe" for now and the foreseeable future. The science is generating papers at a rate of about 10 per week.

The radiation damage was discussed and longer-duration observations, which have to go through the peer review process now. It's clear Chandra ought to get up to 10 million seconds of observation time for surveys. That is too much time for peer review proposal, but a strategic NRA could be done with help from the community. The subcommittee offered to help with that.

Close-Out with Anne Kinney

Rocky Kolb asked Anne Kinney about the Cycles of Matter and Energy part of roadmap. How would A&P use this roadmap? SEU was told not to have a shopping list, but can it have more of a list in the second part of the roadmap? In Beyond Einstein, is three the right number for Cosmic Probes?

Anne Kinney replied that, for programmatic advocacy, shopping lists are never good. They make it sound like you always want more. We have other routes for Explorer missions. They refer back to roadmaps for science that NASA is interested in. They want the roadmaps to be broader science issues. She sees Cosmic Probes as a line. Three is a great number. The point is to get an SEU line. Other themes have a program line.

Joel Bregman asked about how missions get followed up on. In the Cycles program, SEU talks about all this great science, will we continue to pursue it through Explorer and possibly in the future?

Dr. Kinney replied that the discussion helps the R&A program that refers back to the roadmap. Proposals on detector development and other research programs refer back to the roadmap science. The biggest goal is to do the science. The suggested missions provide examples of a way to do the science. The roadmap has the science questions we need to be answering. SEU has suffered in the past from the perception that SEU wants all these missions and they're big. The most powerful thing is to express what you are trying to do. Put the science first. Do it sincerely from the heart and mind of a scientist. Often those questions also are of greatest interest to the public.

There was some discussion about other sectors of the community that would be left out of the program line and international cooperation to lower costs or leverage funds.

Dr. Kolb asked about the Ultra-Long Duration Ballooning program. Do you have a plan for how missions would be proposed? If balloon missions have Explorer-class budget lines, how do you implement them without losing the infrastructure to develop a mature program?

Dr. Kinney pointed out the budget for balloon program budget was increased by \$4 million this year based on science productivity of that line. In its letter, SEUS needs to comment on the progress of the roadmap team. Dr. Kinney was very happy with that and to have everyone see the Chandra science update press conference. She has been concerned about publicity for Chandra. The science is hard to communicate and understand. It requires a community that's willing to spend the time to develop the results and communicate them. Chandra does amazingly well.

Mission Updates 2—Status of Upcoming Missions

Gamma Ray Large Area Space Telescope (GLAST)

Dr. Steven Ritz explained that GLAST connects the high-energy particle and astrophysics communities in the study and discovery of supermassive black holes, gamma ray bursts, the origin of cosmic rays, and galaxy formation.

In the programmatic stage, GLAST has a Science Working Group, of which Charles Dermer is a member, that addresses scientific issues in topical meetings, science sessions at major conferences, and on a web page for meeting minutes and activities. The Science Support Center at Goddard is ramping up, designing science tools and software and database standards. The user committee will oversee the design of the Science Support Center.

The Delta 2920H heavy launch vehicle was baselined for the mission. Request for Offers (RFO) are going out to acquire the spacecraft. Requirements must be precise because the acquisition is fixed-price. A propulsion system is now part of the design planning, which moves up the center of gravity of the observatory.

Lynn Cominsky is the lead for E/PO and PR. GLAST has the ambassador program that trains teachers to train other teachers and a GLAST exhibit booth. A PBS TV show is being discussed with Tim Lucas.

Engineering models for flight hardware have been developed. In January NASA signed an agreement with DOE. Most of the systems have passed PDR, except the boundaries on the thermal system were expanded, delaying that review.

Dr. Ritz discussed the instruments and their status. There is a problem with French CNES funding for GLAST calorimeter, which slip the schedule. The NRL could do what French were going to do without a significant slip in schedule if we found enough money.

The demonstration balloon flight August 4th was to show the ability to take data in a highly isotropic environment at a high rate and met all objectives.

Galaxy Evolution Explorer (GALEX)

The science objectives and questions that Dr. David Schminovich said GALEX addressed were: the history of star formation, the formation of stars and metals, why galaxies evolve, and the development of cosmological models. GALEX complements the high red-shift measurements of Hubble and the Next Generation Space Telescope and allows a connection to the local area by measuring lower red shift.

The astronomical community is missing a full sky survey in UV as a resource. GALEX was selected as a Small Explorer (SMEX) in the Fall 1997. It will be launched on July 30, 2002, on a Pegasus for a 28-month mission. The first data releases are expected in December of 2003. The mission was descoped by 20%, which may affect the quality of calibration three years down the road.

The spacecraft will do a number of surveys: all-sky imaging survey, deep imaging survey, wide (shallow) spectroscopic survey, plus medium and deep. They plan to overlap observations with many targets measured in IR and provide local analogs to distance galaxy observations by HST.

Most satellite-level tests are finished. They are getting ready to send the satellite down to the Cape.

Mission Updates 3—Status of Possible Roadmap Near-Term Missions

Constellation X-ray (Con-X) Mission

Dr. Nicholas White updated the subcommittee on the Con-X mission progress. The Con-X mission is extremely ambitious. It plans to put four satellites launched two at a time on an Atlas-V at L2 in a deep-space orbit that allows a high observing efficiency.

The observing program will be revised based on other sample observations. The reference mission architecture and design document are being revised based on results from NGST. It will take two or three hours to download each satellite. The team has to relook at using DSN versus using their own dish. Chandra, with low throughput, can be a finder for Con-X with its high throughput.

The object is to observe the effect of general relativity near black hole event horizons. The Con-X spacecraft is optimized for high resolution x-ray spectroscopy in the mainstream of astronomy. It does x-ray spectroscopy with high throughput and high resolution spectroscopy of faint x-ray source populations. It looks at the evolution of black holes through red shift, dark matter and energy throughout universe. Con-X should be helpful to determine the nature of the faint x-ray sources discovered by Chandra.

The baseline mission concept started with a CAN with industry years ago. There will be a pre-phase A study selection with multiple contractors in FY03 and an instrument AO late in '04. The tall pole for the engineering unit is the SXT optic to be completed the first quarter of '04. TPF, NGST, and Con-X are participating in a joint technology initiative to develop cryocoolers for their similar requirements. The program has \$6 million this year and \$12 million next year.

The subcommittee debated the relative merits of x-ray versus radio for studying black holes.

Laser Interferometer Space Antenna (LISA)

Dr. Tuck Stebbins explained that LISA is a three-spacecraft constellation that uses interferometry to measure changes in the distance between masses caused by gravitational waves. The purpose is to detect gravitation radiation from compact binary star systems in our galaxy and possibly observe gravitational radiation from the universe. Researchers expect to see thousands of these systems when the instruments are turned on. They expect lots of sources including close white dwarf binaries.

Dr. Stebbins went into some of the planning and management issues required in the close collaboration between ESA, JPL, and GSFC the mission requires. They worked through Code I on ITAR requirements for sharing design code with ESA. ESA has to assign components of the payload to various member states. They have worked for a sensible assignment of components that can be handed off to an integrator. With an international program, there are integration and test issues, export licenses, issues of what goes across the Atlantic how many times. The design of instruments is driven by the ability to test them.

The mission is in pre-formulation. They have a draft MOU that they are working forward and staffing up. They have added contractor support at Goddard, particularly in integrated modeling. They are taking an aggressive approach to modeling to work through the requirements. LISA can't be deploy tested on the ground. Disturbance reduction is the challenge. LISA needs performance that is three to four orders-of-magnitude better than before. The New Millennium ST-7 mission will demonstrate LISA technology aboard the European Smart-2 mission. This mission was just selected for a disturbance reduction system.

The technology assessment was completed in February. They have draft science requirements documented. The LISA International Science Team (LIST) has 10 U.S. and 10 European members.

DOE/HEPAP Planning and Roadmap

Dr. J. Bagger reported on the planning process of the High Energy Physics Advisory Panel (HEPAP) last year to formulate a long-range plan for high-energy physics. The panel held Town Meetings at national laboratories and talked to NSF and DOE while trying to keep their eyes on the science. They consulted 1,000 particle physicists at Snowmass, CO, and laboratory directors from Europe and Asia and other non-U.S. laboratories. They studies different modes and models of international partnership on large projects—NASA, ITER, ALMA, Gemini, TESLA.

The planning is for the U.S., but global in context. The panel looked at how particle physics fits into society and education and identified opportunities for science over the next 20 years.

The 1957 definition of particle physics was, "The nature and properties of the fundamental constituents of matter and the forces interacting between them." The panel's definition was, "The science of matter, energy, space and time and how they interact together." That includes cosmology, hidden dimensions, the ultimate unification, and the search for the DNA of matter. The last quark was discovered in the last 5 years. That is the end of finding the fundamental particles. The field has done well in last 5 years despite superconducting collider cancellation. Particle physics is not accelerators: it's defined by the above questions, not by the tools.

HEPAP's roadmap is a list of opportunities and mechanism for prioritizing. Projects include:

- Energy Frontier
- Lepton Flavor Physics
- Quark Flavor Physics
- Unification Scale Physics
- Cosmology
- Particle Astrophysics

What is the next big step? Increasing the level of energy with a new linear collider somewhere in world. The cost would be about \$5-7 billion. Two-thirds of the cost would be financed by the host country. International investment would be about \$1 billion. Some of the existing U.S. high-energy physics program money could be redirected over the next 20 years, leaving \$2-3 billion in new money, only a 30-40% increase in the particle physics budget.

The community needs to unite behind a common vision, then carry the message to neighboring fields of science and then further fields, working together to enlarge the envelop for physics.

Planning For Future Meetings

The committee agreed on August 12 and 13 in Washington for the next meeting. [Note added: the meeting dates have been moved to August 9-10.]

Final Discussion

The chair invited final comments on concerns from subcommittee members.

Joel Bregman thought the roadmap looked good. I'm concerned that the general goals except for LISA and Con-X should be stated without drawing in the wavelength region, making it as general as possible to give flexibility and focus directly on the science. I'm a little concerned about roadmap 2 and how it will be couched. We want SEU to be open to seeking breakthroughs in technology.

Lynn Cominsky thought the roadmap was a great start, but we didn't have much time to talk about it. When do we get to do a detailed review? The devil is in the details.

Charles Dermer echoed Dr. Cominsky's concerns. The roadmap is somewhat narrowly focused. We want to be inclusive, not exclusive. This should be worked through. Money for technology didn't get a proper discussion here. It seems like it would be targeted toward cosmological themes.

Sterl Phinney corrected the technology money assertion: There are two paths to get technology. Technology is part of Beyond Einstein, and there is technology money for Cycles of Matter and Energy. We will keep the current draft of the on roadmap on the website, and you can read the 21 white papers on the website.

Rocky Kolb stated the Beyond Einstein program is about \$3 billion. Technology is maybe 5% of programs.

Kathy Flanagan would like to endorse and congratulate the roadmap team. Sign me off on Part I. I invite others to get behind the approach developed by the roadmap team.

Jackie Hewitt agreed with the areas of science chosen. I would change in the Einstein probes, while there should only be three probes, not necessarily three questions.

Daniel Lester thought the process was a great improvement over that of the last roadmap. I am very pleased with Beyond Einstein. It is not my science, but it is beautiful. I will encourage my community to support this program line because SEU needs something like this. I agree that raising SEU's fortunes will raise all ships. I agree with comments that have been made. I am concerned about the second part of the roadmap—what goes in it and how it is spun. Part of my concern is that we don't have a front section for it yet. I think that will determine how well the community accepts the roadmap.

Sterl Phinney was most concerned about the second part of the roadmap. I haven't gotten anyone to produce anything yet. It needs to explain the science and justify the technology areas. He asked for contributions. Charles Dermer asked if he had an outline for the document, which he did.

Simon Swordy felt the fundamental problem is you need to put together a cohesive program, but you can't include everything. We've got a good focused program. What do you do about everybody else? Now all of us can help figure

out what to do about everybody else. If I'm not in the second part of the roadmap, I'm going out of business. I would like to make sure it supports the breadth of our field. We don't just have to do accelerators. We can do gravitational waves, IR, and other things.

Nick White thought the process was much more productive than in the past. I don't disagree with the statements about keeping these things generic. We do have to make sure everything hangs together and demonstrate how things are interlinking and dependent. Be careful not to water down the message too much. I invite people to get behind Beyond Einstein. For Cycles, we need to do more work with Origins people to figure out a common line.

Ned Wright was concerned about the ambition of the flagship missions. LISA is pretty far in the future, but Con-X is supposed to be bigger and better than Chandra and Newton. The story of the great observatories is huge expense (Hubble \$1 billion, SIRTf just under a billion). I wouldn't count on getting 10,000 kilograms to L2. I think we need to think further on the cost of these things. Nick wanted a program plan where you can't pull out any one piece. I don't understand why you wouldn't want to encourage support of part of the missions.

Harold Yorke liked and endorsed the strategy of two part roadmap and the focused Beyond Einstein program. I have some concern about how the second part of the roadmap will look. You do want to emphasize exciting science, but you need strawman missions, a way to do it. I agree with the comment by Jackie about just doing a black hole survey. Just doing a black hole survey is not exciting unless you explain the science. I am not convinced X-ray is the only way to image a black hole close to the event horizon and the way we would decide to do this in the next couple years. I think we should continue on the path and clean up the document.

Dr. Kolb thanked the committee and adjourned the meeting.

AGENDA

Structure and Evolution of the Universe Subcommittee (SEUS)

April 9-10, 2002

NASA Headquarters

Room 9H40

Tuesday, April 9

8:30– 9:00	R. Kolb	Introduction of New Members
9:00–10:00	A. Kinney	Astronomy & Physics Division Update
10:00–10:45	P. Hertz	SEU Theme Update
10:45–11:00		Break
11:00–12:00	E. Weiler	OSS and Budget Update
12:00– 1:00	S. Kahn, J. Turner	Lunch Seminar: New XMM Results
1:00– 1:45	S. Phinney	Roadmap Team Update – Strategy
1:45– 2:00	S. Kahn	Roadmap Team Technology Update
2:00– 2:30	All	Committee Discussion on Strategy
2:30– 2:45		Break
2:45– 3:15	S. Phinney	Roadmap Team Update – Missions
3:15– 3:45	All	Committee Discussion on Missions
3:45– 4:15	S. Phinney	Roadmap Team Update – High Level Questions
4:15– 4:30	R. Gould	Roadmap Team EPO Update
4:30– 5:00	All	Committee Discussion on High Level Questions
5:00 – 5:30	R. Kolb	Discussion of OSS Initiatives, Funding Lines, Etc.
5:30		Adjourn

Wednesday, April 10

8:30– 8:45	All	General Committee Discussion
8:45– 9:10	All	Discussion of Cosmic Probes
9:10– 9:25	All	Discussion of Issues To Be Raised With Kinney/SScAC
9:30–10:30	NASA Auditorium	Break—Chandra Space Science Update,
10:30–11:20		Mission Updates 1—Status of Operating Missions
	G. Henshaw	MAP
	M. Weisskopf	Chandra
11:20–12:10		Mission Updates 2—Status of Upcoming Missions
	S. Ritz	GLAST
	D. Schminovich	GALEX
12:10– 1:30	A. Kinney	Lunch and Close-Out with Kinney
1:30– 2:00	J. Bagger	DOE/HEPAP Planning and Roadmap
2:00– 2:50		Mission Updates 3—Status of Possible Roadmap Near-Term Missions
	N. White	Con-X
	R. Stebbins	LISA
2:50– 3:10		Break
3:10– 3:30	R. Kolb	Planning For Future Meetings
3:30– 4:00	All	Final Discussion
4:00		Adjourn

STRUCTURE AND EVOLUTION OF THE UNIVERSE SUBCOMMITTEE (SEUS)
MEMBERSHIP LIST

Dr. Edward W. Kolb (Chair)
CERN
TH Division, Room 4-2-050
CH-1211 Geneva 23
Switzerland
TEL: +41-22-767-2447
FAX: +41-22-767-3850
Email: Rocky.Kolb@cern.ch

Dr. Joel Bregman
Professor of Astronomy
University of Michigan
Department of Astronomy
500 Church Street
830 Dennison Building
Ann Arbor, MI 48109-1090
TEL: (734) 764-3454
FAX: (734) 763-6317
Email: jbregman@astro.lsa.umich.edu

Dr. Lynn R. Cominsky
Department of Physics and Astronomy
Sonoma State University
1801 East Cotati Avenue
Rohnert Park, CA 94928-3609
TEL: (707) 664-2655
FAX: (800) 848-6369
Email: lynnr@charmian.sonoma.edu

Dr. Charles D. Dermer
Code 7653
Naval Research Laboratory
4555 Overlook Avenue, SW
Washington, D.C. 20375-5352
TEL: (202) 767-2965
FAX: (202) 767-6473
Email: dermer@gamma.nrl.navy.mil

Dr. Kathryn Flanagan
Room NE80-6103
Center for Space Research
Massachusetts Institute of Technology
77 Massachusetts Avenue
Cambridge, MA 02139
TEL: (617) 258-7324
FAX: (617) 253-8084
Email: kaf@space.mit.edu

Dr. Timothy M. Heckman
Bloomberg 523
Department of Physics and Astronomy
The Johns Hopkins University
3400 North Charles Street
Baltimore, MD 21218-2686
TEL: (410) 516-7369
FAX: (410) 516-5096
Email: heckman@pha.jhu.edu

Dr. Jacqueline N. Hewitt
Department of Physics
Room 37-241
Center for Space Research
Massachusetts Institute of Technology
70 Vassar Street
Cambridge, MA 02139
TEL: (617) 253-3071
FAX: (617) 253-3111
Email: jhewitt@space.mit.edu

Dr. Daniel Lester
Department of Astronomy
Mail Code C1400
Robert Lee Moore Hall 15.308
University of Texas
Austin, TX 78712
TEL: (512) 471-3442
FAX: (512) 471-6016
Email: dfl@astro.as.utexas.edu

Dr. Bradley Peterson
Department of Astronomy
Ohio State University
140 West 18th Avenue
Columbus, OH 43210-1106
TEL: (614) 292-7886
FAX: (614) 292-2928
Email: Peterson@astronomy.ohio-state.edu

Dr. E. Sterl Phinney
Mail Stop 130-33
California Institute of Technology
1200 E. California Boulevard
Pasadena, CA 91125
TEL: (626) 395-4308
FAX: (626) 796-5675
Email: esp@tapir.calech.edu

Dr. Simon Swordy
Laboratory of Astrophysics and Space Research
University of Chicago
933 East 56th Street
Chicago, IL 60637-1460
TEL: (773) 702-7835
FAX: (773) 702-6645
Email: s-swordy@uchicago.edu

Dr. Nicholas E. White
Code 660.0
Goddard Space Flight Center
National Aeronautics and Space Administration
Greenbelt Road
Greenbelt, MD 20771
TEL: (301) 286-8443
FAX: (301) 286-0250
Email: nwhite@lheapop.gsfc.nasa.gov

Dr. Edward L. Wright
Professor of Astronomy
Department of Astronomy
University of California at Los Angeles
P.O. Box 951562
Los Angeles, CA 90095-1562
TEL: (310) 825-5755
FAX: (310)n 206-2096
Email: wright@astro.ucla.edu

Dr. Harold W. Yorke
MS 169-506
Jet Propulsion Laboratory
National Aeronautics and Space
Administration
4800 Oak Grove Drive
Pasadena, CA 91109-8099
TEL: (818) 354-0336
FAX: (818) 354-8895
Email: harold.w.yorke@jpl.nasa.gov

Dr. Paul Hertz (Executive Secretary)
Office of Space Science
NASA Headquarters
300 E Street, SW
Washington, DC 20546-0001
TEL: (202) 358-0986
FAX: (202) 358-3096
Email: phertz1@mail.hq.nasa.gov

MEETING ATTENDEES

Subcommittee Members:

Kolb, Edward W. (*Chair*)
Bregman, Joel
Cominsky, Lynn R.
Dermer, Charles D.
Flanagan, Kathryn
Hertz, Paul (*Executive Secretary*)
Hewitt, Jacqueline
Lester, Daniel
Phinney, E. Sterl
Swordy, Simon
White, Nicholas
Wright, Edward
Yorke, Harold

CERN
University of Michigan
Sonoma State University
Naval Research Laboratory
Massachusetts Institute of Technology
NASA Headquarters
Massachusetts Institute of Technology
University of Texas
California Institute of Technology
University of Chicago
NASA/GSFC
University of California at Los Angeles
NASA/JPL

NASA Attendees:

M. Audy
D. Beasley
Phil Crane
Paul DeMinco
Jay Frogel
Neil Gehrels
Barry Geldzahler
Hashima Hasan
Paul Hertz
W. Vernon Jones
Anne Kinney
Donald Kniffen
Melvin Montemerlo
Mike Moore
Marian Norris
Ruth Netting
Steve Ritz
Phil Sakimoto
Michael Salamon
N. Sill
Eric Smith
Chris Schwartz
Frank Six
R. Stebbins
Robert Streitmatter
Ron Ticker
Jane Turner
G. Varsi
Martin Weisskopf
G. Withbroe

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NASA/GSFC
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NASA/GSFC
NASA Headquarters
NASA Headquarters
NASA Headquarters
NASA Headquarters
NASA Headquarters
NASA Headquarters
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NASA/MSFC
NASA Headquarters
NASA/GSFC
NASA/GSFC
NASA/GSFC
NASA/GSFC
NASA Headquarters
NASA/MSFC
NASA Headquarters

Other Attendees:

Sarah Church
Dom Conte
Ed Fomalont
Steven Kahn
Kathy Turner

Stanford University
Spectrum Astro
NRAO
Columbia University
Department of Energy

FINDINGS AND RECOMMENDATIONS

[letter from Dr. Kolb to Dr. Kinney to be inserted here]

LIST OF PRESENTATION MATERIAL¹

1. "GLAST Large Area Telescope: Status Report to SEUS," Steven Ritz
2. "Constellation X-ray Mission," Nicholas White
3. "Laser Interferometer Space Antenna (LISA) Status," Tuck Stebbins
4. "SEU Update," Paul Hertz
5. "Space Science Enterprise: FY2003 President's Budget Key Features," Edward Weiler
6. "The Case for General Relativistic Effects I the Iron Line Profile of NGC 3516," Jane Turner
7. "Key Points for the E/PO Component," Roy Gould
8. "MAP," Gary Henshaw
9. "Chandra," Martin Weisskopf
10. "GALEX," David Schminovich
11. "DOE/HEPAP Planning and Roadmap," Jonathan Bagger

Other material distributed at the meeting:

- 1) Roadmap draft, Sterl Phinney

¹ Presentation and other materials distributed at the meeting are on file at NASA Headquarters, Code S, Washington, DC 20546.